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Search History

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L36	L13 and (monitor$ same accelerat$)	0	L36
L35	L13 and (monitor$ with accelerat$)	0	L35
L34	L33 and (wheel$ with sens$)	3	L34
L33	L32 and (correct$ with (distanc$ or accelerati$))	13	L33
L32	L30 and 701/19.ccls.	39	L32
L31	L30 and 701/29.ccls.	18	L31
L30	(train or locomotive) and (distanc$ and accelerati$) and @ad<=20031126	7243	L30
L29	L27 and curvature	4	L29
L28	L27 and grade	1	L28
	(map$ same index$) and (curv$ or grad$) and @ad<=20031126 and		

L27	(index$ same (map$ same curv$) and distance and gps)	13	L27
L26	L24 not l25	2	L26
L25	L24 and l22	5	L25
L24	L21 and (index$ same (map$ same curv$) and distance and gps)	7	L24
L23	L22 and 701/29.ccls.	0	L23
L22	L21 and (wheel with sensor$) and distance and gps	7	L22
L21	(train or locomotive) and (map$ same index$) and (curv$ or grad$) and @ad<=20031126	249	L21
L20	L1 and (map$ same index$) and (curv$ or grad$)	0	L20
L19	L13 and ((speed$ or velocit$) same (thres$ or refer$))	1	L19
L18	L13 and ((rotat$ with wheel) same (tim$ or interval or duration or period$))	1	L18
L17	L13 and ((rotat$ with wheel) same (tim$ or interval))	1	L17
L16	L13 and ((rotat$ with wheel) with (tim$ or interval))	0	L16
L15	L13 and ((rotat$ with wheel) same interval)	0	L15
L14	L13 and (rotation with wheel)	1	L14
L13	6446005.pn.	1	L13
L12	L1 and ((amount or number$) with (rotat$ or turn$))	1	L12
L11	L1 and (start$ and (stop$ or destinat$))	0	L11
L10	L1 and (start$ same (stop$ or destinat$))	0	L10
L9	L1 and (speed$ with correct$)	3	L9
L8	L1 and (rotat$ with sens$)	2	L8
L7	L1 and (distance same (gps or position$) same error)	1	L7
L6	L1 and ((gps or position$) same error)	2	L6
L5	L1 and (correction$ with (error or factor$ or coeficient or k$))	1	L5
L4	L1 and (correction$ with (error or factor$ or coeficient))	1	L4
L3	L1 and (correction$ with (factor$ or coeficient))	1	L3
L2	L1 and (train or locomotiv$)	2	L2
L1	6148269.pn. or 6681160.pn. or 6446005.pn.	3	L1

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L37: Entry 1 of 1 File: USPT Sep 3, 2002

DOCUMENT-IDENTIFIER: US 6446005 B1
TITLE: Magnetic wheel sensor for vehicle navigation system

Brief Summary Text (24):
Mechanical issues addressed in the implementation of sensors of the ACUTRAK system on a golf cart include (1) selection and mounting of the wheel sensor used for measuring distance traversed by the cart, and (2) selection and mounting of the electronic compass used for measuring bearing (direction, relative to a reference direction, typically true north). It is necessary to determine the most desirable or advantageous wheel for location of the wheel sensor on the golf cart. The rear wheels of the cart undergo slippage during rapid acceleration and braking on wet grass; hence, mounting the sensor on a rear wheel is more likely to result in errors in determination of distance traveled by the cart under those conditions. On the other hand, since the front wheels of the cart can turn, wheel velocity is computed along the direction that the wheel is pointed rather than the direction the cart frame is pointed. Resulting error may be overcome mathematically in navigation software for the ACUTRAK system, as described in the '962 application.

6:15-20

Detailed Description Text (31):
In the latter path, the output of magnetic wheel sensor 64 is subjected to application of a wheel scale factor error correction Sf.sub.w from the DGPS/DR calibration at 75, to compensate an error that increases with distance traveled over time. The resulting output undergoes processing similar to that provided in the compass sensor path, as described above, so that the pair of outputs related to wheel speed and acceleration are obtained and applied to develop the compass tilt estimation at 68, while the wheel speed factor is also applied to provide steering compensation at 76. Also applied to the latter are the turn rate (rate of change of heading) factor .omega..sub.m and a factor representing the wheel base of the cart, from which speed (velocity) compensation factors V.sub.x and V.sub.y are derived for application to table calculator 74.

17:5-9

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L22: Entry 7 of 7 File: USPT Nov 30, 1999

US-PAT-NO: 5995895
DOCUMENT-IDENTIFIER: US 5995895 A
**** See image for Certificate of Correction ****

TITLE: Control of vehicular systems in response to anticipated conditions predicted using predetermined geo-referenced maps

DATE-ISSUED: November 30, 1999

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Watt; John D.	Davenport	IA		
McMillen; Richard E.	Sherrard	IL		
Salzman; Gerald E.	Libertyville	IL		
Orsborn; Jesse H.	Port Byron	IL		
Faivre; Stephen M.	DeKalb	IL		
Morrow; James G.	Wauwatosa	WI		
Vogel; Peter J.	Whitefish Bay	WI		

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Case Corporation	Racine	WI			02

APPL-NO: 08/ 892789 [PALM]
DATE FILED: July 15, 1997

INT-CL: [06] B60 K 31/02, G06 F 19/00

US-CL-ISSUED: 701/50; 701/93, 701/208, 701/213, 56/10.2R, 56/10.2G
US-CL-CURRENT: 701/50; 56/10.2G, 56/10.2R, 701/208, 701/213, 701/93

FIELD-OF-SEARCH: 701/50, 701/207, 701/213, 701/208, 701/52, 701/53, 701/56, 701/93, 701/58, 701/68, 701/65, 342/357, 342/457, 342/357.06, 342/357.13, 342/357.17, 56/1.2R, 56/1.2A, 56/1.2B, 56/1.2C, 56/1.2G, 56/11.1, 56/11.3, 56/11.9

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

Search Selected Search ALL Clear

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
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☐				
☐	4171029	October 1979	Beale	180/54R
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☐	4346303	August 1982	Bukatarevic	290/45
☐	4348855	September 1982	DePauw et al.	56/10.2
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☐	4495451	January 1985	Barnard	318/150
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☐	4934985	June 1990	Strubbe	460/4
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☐				
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Bloom et al.; Precision Farming from Rockwell; IEEE 1996 Position Location and Navigation Symposium; Atlanta, GA; Apr. 22-26, 1996.
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Using DGPS to Improve Corn Production and Water Quality; by Tracy M. Blackmer and James S. Schepers; GPS World; pp. 44-52; Mar. 1996.
Development of a Field-Scale GIS Database for Spatially-Variable Nitrogen Management; by Baojin Zhang; ASAE 94-355D; 1994.
Investigation of a Feedrate Sensor for Combine Harvesters; by N.D. Klassen, S.N. Pang, R.J. Wilson and J.N. Wilson; ASAE 93-2428; 1993.
Control System for Combine Harvesters; by W.M. Kotyk, T.G. Kirk, M.D. Plassen, J.N. Wilson and En-Zen Jan; date unknown.

ART-UNIT: 361

PRIMARY-EXAMINER: Zanelli; Michael J.

ATTY-AGENT-FIRM: Foley & Lardner

ABSTRACT:

A control system for controlling a vehicle system at least partly in response to an anticipated condition along the vehicle's course of travel is disclosed herein. The vehicle includes a drive train powered by an engine, and the anticipated condition may affect engine load. The control system includes a location signal generation circuit for receiving positioning signals and generating location signals therefrom, a memory circuit for storing a predetermined geo-referenced map including map data indicative of anticipated conditions along the course of travel which may affect engine load, and a control circuit. The control circuit predicts the anticipated condition using at least the location signals and the map data, generates a control signal based at least upon the anticipated condition, and applies the control signal to the vehicle system. The prediction of the anticipated condition can be calibrated using results of a comparison between a sensed actual condition and an earlier-predicted anticipated condition. Anticipated conditions include anticipated slopes, crop conditions and soil conditions. Crop conditions can be anticipated using aerial photography. The controlled vehicle systems include speed actuators, transmissions, crop processors, energy exchangers, clutches and differential locks.

59 Claims, 15 Drawing figures

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L34: Entry 2 of 3 File: USPT Feb 12, 2002

US-PAT-NO: 6347265
DOCUMENT-IDENTIFIER: US 6347265 B1

TITLE: Railroad track geometry defect detector

DATE-ISSUED: February 12, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Bidaud; Andre C.	Burnaby			CA

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Andian Technologies Ltd.	Burnaby			CA	03

APPL-NO: 09/ 594286 [PALM]
DATE FILED: June 15, 2000

PARENT-CASE:
This application claims the benefit of U.S. Provisional Application Nos. 60/139,217, filed Jun. 15, 1999, and 60/149,333, filed Aug. 17, 1999.

INT-CL: [07] B61 L 23/04

US-CL-ISSUED: 701/19; 73/146
US-CL-CURRENT: 701/19; 73/146

FIELD-OF-SEARCH: 701/19, 73/146

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

Search Selected Search ALL Clear

	PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
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☐	5956664	September 1999	Bryan	702/184
☐	5987979	November 1999	Bryan	73/146
☐	6044698	April 2000	Bryan	73/146
☐	6125311	September 2000	Lo	701/29

FOREIGN PATENT DOCUMENTS

FOREIGN-PAT-NO	PUBN-DATE	COUNTRY	US-CL
0561705	September 1993	FR	

ART-UNIT: 3661

PRIMARY-EXAMINER: Zanelli; Michael J.

ASSISTANT-EXAMINER: Gibson; Eric M

ATTY-AGENT-FIRM: Fay, Sharpe, Fagan, Minnich & McKee, LLP

ABSTRACT:

A track analyzer included on a vehicle traveling on a track includes a vertical gyroscope for determining a grade and an elevation of the track. A rate gyroscope determines a curvature of the track. A speed determiner determines a speed of the vehicle relative to the track. A distance determiner determines a distance the vehicle has traveled along the track. A computing device, communicating with the vertical gyroscope, the rate gyroscope, the speed determiner, and the distance determiner, a) identifies a plurality of parameters as a function of the grade, elevation, and curvature of the track, b) determines in real-time if the parameters are within acceptable tolerances, and, c) if the parameters are not within the acceptable tolerances, generates corrective measures.

17 Claims, 14 Drawing figures

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L34: Entry 2 of 3 File: USPT Feb 12, 2002

DOCUMENT-IDENTIFIER: US 6347265 B1
TITLE: Railroad track geometry defect detector

Abstract Text (1):
A track analyzer included on a vehicle traveling on a track includes a vertical gyroscope for determining a grade and an elevation of the track. A rate gyroscope determines a curvature of the track. A speed determiner determines a speed of the vehicle relative to the track. A distance determiner determines a distance the vehicle has traveled along the track. A computing device, communicating with the vertical gyroscope, the rate gyroscope, the speed determiner, and the distance determiner, a) identifies a plurality of parameters as a function of the grade, elevation, and curvature of the track, b) determines in real-time if the parameters are within acceptable tolerances, and, c) if the parameters are not within the acceptable tolerances, generates corrective measures.

Application Filing Date (1):
20000615

Brief Summary Text (9):
A track analyzer included on a vehicle traveling on a track includes a vertical gyroscope for determining a grade and an elevation of the track. A rate gyroscope determines a curvature of the track. A speed determiner determines a speed of the vehicle relative to the track. A distance determiner determines a distance the vehicle has traveled along the track. A computing device, communicating with the vertical gyroscope, the rate gyroscope, the speed determiner, and the distance determiner, a) identifies a plurality of parameters as a function of the grade, elevation, and curvature of the track, b) determines in real-time if the parameters are within acceptable tolerances, and, c) if the parameters are not within the acceptable tolerances, generates corrective measures.

Brief Summary Text (11):
In accordance with another aspect of the invention, an analog-to-digital converter converts analog signals from the vertical gyroscope, the rate gyroscope, the speed determiner, and the distance determiner into respective digital signals which are transmitted to the computing device.

Drawing Description Text (11):
FIG. 9 illustrates a distance determiner according to the present invention;

Drawing Description Text (14):
FIG. 12 illustrates a graph of degree-of-curvature versus distance according to the present invention;

Detailed Description Text (10):
With reference to FIG. 6, a speed determiner (e.g., a speedometer) 70, including a toothed gear 72 and a pick-up (sensor) 74, is connected to a free-spinning rail wheel 78 contacting the track 10. The free-spinning rail wheel 78 is chosen, as opposed to a driven wheel, to eliminate errors due to acceleration slippage or brake skidding.

Detailed Description Text (12):
With reference to FIG. 9, a distance determiner (e.g., an odometer) 91 includes first and second light sources 100, 102, respectively, and first and second light detectors 104, 106 (e.g., photocells), respectively, positioned near slots 110 in first and second plates 112, 114, respectively, along an axis 92 including the wheel 78. The distance determiner 91 acts to measure distance that the vehicle 28 travels. The plates 112, 114 are preferably positioned such that a slot 110 in the first plate 112 "leads" a slot 110 in the second plate 114 by about 1 degree, thereby forming a quadrature encoder.

Detailed Description Text (13):
With reference to FIGS. 1 and 8-10, electrical pulses 116, 118 are received by the detectors 104, 106 when light from the sources 100, 102 passes through the slots 110 in the respective plates 112, 114. The space between each of the slots 110 is known. Furthermore, each of the plates 112, 114 rotates as a function of the distance the vehicle travels. As indicated by the dotted lines in FIG. 10, the pulses 116, 118 are out-of-phase by about 1 degree. The electrical pulses 116, 118 are transmitted from the detectors 104, 106 to the computing device 42, which determines the distance the vehicle 28 has moved as a function of the number of pulses produced. Also, the direction in which the vehicle 28 is moving is determined by whether the phase of the first plate 112 leads/lags the phase of the second plate 114.

Detailed Description Text (14):
The distance is preferably determined in one of two ways. The distance determiner 91 requires the vehicle 28 to start at, and proceed from, a known location. For example, the vehicle 28 may proceed between two (2) "mile-posts." Alternatively, a differentially corrected global positioning system ("GPS") is used with vehicles where manual intervention is not available. More specifically, the position of the vehicle 28 is obtained from the GPS. Then, the distance determiner 91 is used to update the position of the vehicle 28 between the GPS transmissions (e.g., if the vehicle is in a tunnel).

Detailed Description Text (16):
With reference to FIGS. 1 and 11, a degree-of-curve is defined as an angle a subtended by a chord 120 (e.g., 100 foot). The distance determiner discussed above is used to calculate the chord 120 distance. Also, the rate gyro and speed determiner discussed above are used to determine the degree-of-curve. More specifically, the rate gyro 50 (see FIG. 4) and the speed determiner 70 (see FIG. 6) may determine a certain rate in degrees/foot. That rate is then multiplied by the length of the chord 120 (e.g., 100 feet), which results in the degree-of-curve. The degree-of-curve represents a "severity" of a particular curve in the track 10.

Detailed Description Text (17):
FIG. 12 represents a graph 121 of degree-of-curvature versus distance. As a vehicle enters/exits a curve in a track (see, for example, FIG. 5), the degree-of-curvature changes. While the vehicle is on straight track (e.g., a tangent) or in the body of a curve having a constant radius, the degree-of-curvature remains about constant 122, 123, respectively. A point 124 represents a beginning of an entry spiral; a point 125 represents an end of the entry spiral/beginning of a curve; a point 126 represents an end of the curve/beginning of an exit spiral; and a point 127 represents an end of the exit spiral. The entry and exit spirals represent transition points between straight track and the body of a curve, respectively. Determining whether the vehicle is on a straight track (tangent), a spiral, or a curve is important for determining what calculations will be performed below.

Detailed Description Text (22):
4) Maximum Allowance Runoff (MAR) Tolerances that, when exceeded, identify potentially unsafe uniform rise/falls in both rails over a given distance.

Detailed Description Text (34):
The variations in the cross-level are related to speed. The designation is the "legal freight speed" for a section of track. This designation is defined in another set of tables, which relate freight speed to actual track position (mileage). Therefore, the system is able to determine the distance (mileage) and, therefore, looks-up the legal track speed for that specific point of track. The system is able to determine whether the vehicle is on tangent (straight) track, curved track, or spiral track from the graph shown in FIG. 12. An example of calculations for tangent (straight) track are discussed below.

Detailed Description Text (35):
To determine whether the vehicle is on tangent (straight) track, curved track, or spiral track, the system takes a snap-shot of all the parameters at one foot intervals, as triggered by the distance determiner. Therefore, the system performs such calculations every foot. The data are then statistically manipulated to improve the signal-to-noise ratio and eliminate signal aberrations caused by physical bumping or mechanical "noise." Furthermore, the data are optionally converted to engineering units.

Detailed Description Text (36):
More specifically, at a given time (or distance), if the vehicle is on a tangent (straight) track and traveling 40 mph with an actual cross elevation of 11/8", the system first determines an allowable deviation, as a function of the speed at which the vehicle is moving, from the look-up table including data for urgent defects (UD1). For example, the allowable deviation may be 11/2" at 40 mph. Since the actual cross elevation is 11/8" and, therefore, less than 11/2", the cross elevation is deemed to be within limits.

Detailed Description Text (42):
The device disclosed in the present invention may be mounted in a locomotive rail car. As the locomotive car travels along the track, the device takes continuous readings. For example, the device measures the rail parameters, collects position information of the car along the track, determines out-of-specification rails, and/or stores the particulars of that defect in a memory device, preferably included within the computing device. The system then optionally detects an active cellular area, automatically makes a cellular telephone call and dumps the defect data into a central computer.

Detailed Description Text (43):
The device also notifies a train engineer that the car has run over an out-of-specification track. Furthermore, the system notifies the engineer to slow down the train to remain within safety limits.

Detailed Description Text (45):
The device of the present invention preferably includes an instrument box and a computer assembly. The instrument box is preferably mounted to a frame that accurately represents physical track characteristics. In this manner, the instrument box is subjected to an accurate representation of track movement. In the preferred embodiment, the frame is a Hirail track inspection truck. However, it is also contemplated that the frame be a locomotive.

Detailed Description Text (46):
The instrument box senses (picks-up) the geometry information and converts it so that it is suitable for processing by the computing device. The Hirail is also equipped with both a speed determiner and a distance determiner. In the Hirail configuration, the computing device is mounted in a convenient place. The driver of the vehicle is easily able to view the computer monitor when optionally notified by a "beeping" noise or, alternatively, a voice generated by the computer. If the frame is a locomotive, the computer is placed in a clean, convenient location.

Detailed Description Text (48):
Also, the computing device assembly preferably includes a data acquisition board, quadrature encoder board, a computer assembly, gyroscope power supplies, signal conditioning power supplies, and/or signal conditioning electronics. If the frame is an autonomous locomotive, additional equipment for a digital global positioning unit and a cellular data modem are also included.

Current US Original Classification (1):
701/19

CLAIMS:

1. A track analyzer included on a vehicle traveling on a track, the track analyzer comprising:

a vertical gyroscope for determining a grade and an elevation of the track;

a rate gyroscope for determining a curvature of the track;

a speed determiner for determining a speed of the vehicle relative to the track;

a distance determiner for determining a distance the vehicle has traveled along the track; and

a computing device, communicating with the vertical gyroscope, the rate gyroscope, the speed determiner, and the distance determiner, for a) identifying a plurality of parameters as a function of the grade, elevation, and curvature of the track, b) determining in real-time if the parameters are within acceptable tolerances, and, c) if the parameters are not within the acceptable tolerances, generating corrective measures.

3. The track analyzer as set forth in claim 1, further including:

an analog-to-digital converter for converting analog signals from the vertical gyroscope, the rate gyroscope, the speed determiner, and the distance determiner into respective digital signals which are transmitted to the computing device.

10. A method for analyzing a track on which a vehicle is traveling, comprising:

determining a grade and an elevation of the track;

determining a curvature of the track;

determining a speed of the vehicle relative to the track;

determining a distance the vehicle has traveled along the track;

identifying a plurality of parameters as a function of the grade, elevation, and curvature of the track;

determining in real-time if the parameters are within acceptable tolerances; and

if the parameters are not within the acceptable tolerances, generating corrective measures.

16. The method for analyzing a track on which a vehicle is traveling as set forth in claim 10, wherein the step of determining the distance includes:

producing light from a first source;

passing the light through a plurality of slots in a first plate which rotates as a function of the distance the vehicle travels relative to the track, a spacing between the slots being known;

producing first electrical pulses when light from the first source passes through the slots and is received by a first detector; and

determining the distance the vehicle has traveled along the track as a function of a number of the first pulses received by the first detector.

17. The method for analyzing a track on which a vehicle is traveling as set forth in claim 16, further including:

producing light from a second source;

passing the light from the first and second sources through a plurality of slots in a the first plate and a second plate, respectively, which rotate as a function of the distance the vehicle travels relative to the track, the slots in the first plate being offset a predetermined amount from the slots in the second plate;

producing second electrical pulses when light from the second source passes through the slots and is received by a second detector; and

determining a direction the vehicle is traveling along the track as a function of the first and second electrical pulses.

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L39: Entry 1 of 1 File: USPT Sep 3, 2002

DOCUMENT-IDENTIFIER: US 6446005 B1
TITLE: Magnetic wheel sensor for vehicle navigation system

Detailed Description Text (5):
In the ACUTRAK system, DGPS is preferably used for calibration to limit the buildup of error. Calibration of the dead reckoning (DR) navigation system may be performed at any time satellite LOS is optimal, although it is not necessary that the calibration be continuous or even frequent. Calibration once per hole, or at intervals of 500 yards, is more than sufficient, and suitable LOS conditions would typically be available at least once during that travel interval. An automatically calibrated DR system will continue to perform well to provide high accuracy yardage information to the golfer, without need for any input from the golfer which would represent a distraction from play of the game.

L38: Entry 1 of 1 File: USPT Sep 3, 2002

DOCUMENT-IDENTIFIER: US 6446005 B1
TITLE: Magnetic wheel sensor for vehicle navigation system

Brief Summary Text (16):
The ACUTRAK system is golf cart-based, but could be packaged alternatively in smaller vehicles, even a set of golf bag wheels equipped with a mobile unit or a hand-held unit used with a pedometer version of the wheel-tracking system disclosed in the '962 application. That system utilizes virtually all of the features of the PROLINK system disclosed in the '295 and '905 applications, except that the ACUTRAK system places limited reliance on DGPS, using it as a calibration technique only. In its primary functions the ACUTRAK system employs a dead reckoning system that tracks distance moved by and orientation of the wheels, extrapolated to the heading or bearing of the golf cart (or other roving unit) in which a portion of the overall system is incorporated. The ACUTRAK system is unaffected by even frequent inability to view a satellite navigation system, such as the GPS satellites, requiring only relatively infrequent calibration during play to avoid a gradual increase or buildup of error in measurements as the cart is driven about the course. Thus, instead of experiencing frequent out-of-service indications on the cart monitor, the golfer is cognizant only of continuous, reliable, highly accurate operation of the ACUTRAK system.

Brief Summary Text (31):
According to the invention, then, apparatus is provided for installation on a golf cart to enable calculation of the distance from the cart to a golf cup, a hazard, or other feature of a hole of a golf course which has been surveyed so that the location of such feature is known, from which to make a close approximation of the distance to such feature from a golf ball in a lie proximate to the cart. The apparatus includes a dead reckoning (DR) wheel sensor arrangement for determining speed and direction (forward/reverse) of the cart relative to a tee box of the hole as a known point of origin to which the DR assembly has been calibrated. The arrangement includes a magnetic strip with a plurality of alternating magnetic poles impressed across the strip, which is attached to the rim of a mounting fixture inside the wheel well of the cart. The Hall effect sensor assembly is affixed to the axle of the wheel for detecting passage of the alternating magnetic poles on the strip during rotation of the wheel. A floated compass is attached to the cart, preferably substantially directly above this wheel, to determine the cart heading. Knowing the parameters of speed, forward/reverse direction, and heading of the cart at any given instant relative to the origin enables calculation of real-time distance from the cart to the known location of a feature of interest of the hole being played with the cart.

Brief Summary Text (32):
Selection of the cart wheel to be used for this arrangement is somewhat arbitrary, although as will be noted presently, the left front wheel of the cart is preferred. In one embodiment, the left front wheel was selected to minimize potential errors with the cart's GPS antenna, which was mounted on the left side of the electronics module. Additionally, the driver of the cart sits in the left seat, and therefore a greater frictional force is present on the left front tire than on the right front

tire.

Detailed Description Text (12):
The Hall effect sensor device 30 is a dual element device, in which the two Hall effect sensors 38 and 39 thereof(FIG. 5B) are mounted and positioned a precise distance apart in conjunction with electrical circuitry necessary to drive the Hall effect sensors and produce speed and direction outputs. The two sensors provide the device with the capability to sense movement of the cart in both a forward direction and a backward direction. In the forward direction, one sensor leads the other, whereas in the backward direction, the reverse is true. In the exemplary Allegro A3421 part referred to above, quadrature encoded signals are decoded in the part, and the output signals therefrom are indicative of speed (pulses per second or pps) and direction of the cart. The end of the PCB 32 opposite that to which sensor device 30 is mounted has electrical connections to the conductors of the shielded cable 35 which lead to electrical circuitry of the cart's DR electronics.

Detailed Description Text (14):
After insertion of the PCB 32 with sensor device 30 mounted thereon, but before assembly onto a mounting bracket and connection of grounding lug 33, the metal cylinder 31 is filled with suitable benign potting compound (such as epoxy). This filler serves both to prevent sensor 30 from moving (relative to each of metallic cylinder 31 and external magnetic strip 28), and to serve as a barrier against contamination or fouling as a consequence of the hostile environment of the golf course. The hostility of the course to the DR system of the cart exists from presence of soil, fertilizer, water, mud, debris, and the like which can be churned up onto the wheel hub 43 (FIGS. 3 and 4) and into the wheel well 44 of the wheel 45 on which the wheel sensor assembly 24 is mounted, and onto the wheel sensor assembly 24 itself, as the cart is driven about the course. When the potting compound has cured, the exposed ends of the wire conductors at the opposite end of the four conductor cable 35 are terminated with male connector pins 37 which are then inserted into female connector terminals in the connector body 36.

Detailed Description Text (20):
It is important to observe that as a result of the design provided by the present invention, the lateral alignment of the sensor to the magnetic strip is not crucial. In practice, the wheel sensor assembly bracket is readily attached to the cart, and the wheel is then bolted on in the usual manner, with little or no need for any further adjustment. As noted earlier herein, while either front wheel may be selected as the one with which the assembly is to cooperate, the left front wheel is preferred, taking into account factors such as the location and added weight of the driver of the cart, the location of the antenna for the GPS system to be used for periodic or sporadic calibration of the DR navigation system, and the proximity to fixed sources of potential electrical or magnetic interference on the cart. As a practical matter, the magnetic wheel sensor assembly 24 is installed on a fully assembled cart by removing the designated front wheel 45 from the hub of the cart 50. Once the wheel is removed, the sensor mounting bracket 26 is readily attached to the front axle 51 (or other suitable fixed part of the structure of the vehicle), so as to finally maintain the relative positions of the sensor device 30 and magnetic strip 28 to permit rotation of the latter about the former when the installation of the entire wheel sensor assembly 24 is completed.

Detailed Description Text (21):
By way of example, as illustrated in FIGS. 3, 4, and 6, the magnet mounting fixture 29 of wheel sensor assembly 24 resides in the wheel hub 43 of the front wheel 45 (e.g., on the left, or driver's, side) from its position on the front axle 51 of the golf cart 50. Mounting bracket 26 is slidably positioned along and above front axle 51 with an adjustable collar clamp 52 about its lower leg for rotational alignment of sensor device 30 with magnetic strip 28, i.e., so that the upper end of the Hall effect sensor device is aligned to directly confront the magnetic strip 28 at all times during rotation of the latter about the former, albeit that the two

are maintained at all times in precise spaced-apart relation by the longitudinal alignment of the sensor device. The cable 35 is then routed such that it will not bind or be pinched by any portion of the structure, either while the cart is moving or at a standstill. To that end, as well as to prevent excessive stress or strain on the wire conductor connections of cable 35 to PCB 32 potted within cylinder 31, the cable may be secured to the mounting bracket 26 by a tie-down clamp 58 (FIG. 5). The magnet mounting fixture 29 is slid over the wheel mounting lugs for reinstallation of wheel 45. Upon proper rotational alignment of the sensor device 30 relative to the magnetic strip, the attachment bolts 54 (which have been inserted through respective mating holes in axle bearing mounting flange 56, magnet mounting fixture 29 and wheel hub 43 during the assembly process) are secured by final tightening of nuts 55 thereon, and the collar clamp 52 is tightened to secure the mounting bracket in place in the final assembly. Mounting of the Hall effect sensor device 30 above the axle 51 is preferred because in this location the axle keeps the sensor sheltered from water, mud, soil, rocks, grass, fertilizer, twigs, branches, and other debris that might be encountered as the cart is driven along the course during play. The location of the sensor device 30 inside the wheel well 44 at the rim thereof further protects the sensor. Of course, debris is much less a problem where the cart is used on courses having a "cart path only" rule for driving the golf cart.

Detailed Description Text (23):
The electrical isolation of electrically conductive sensor housing cylinder 31 from mounting bracket 26 prevents conducted electrical noise from being transmitted to the very sensitive Hall effect sensors in element 30 mounted on PCB 32 and potted within the cylinder. This is critical to achieving reliable and accurate magnetic measurements on a vehicle propelled by a pulse width modulated DC electric motor, as is the case with an electric golf cart. Large magnetic and electric fields are produced by such a motor, and shielding is imperative for the magnetic sensor approach of the present invention.

Detailed Description Text (25):
The Hall effect sensor device 30 is supplied with power through the sensor cable 35 by means of a power wire and a ground wire among the four conductors. One of the remaining two conductor wires of cable 35 provides an output signal from the sensor device indicative of speed, the speed signal being composed of digital output pulses whose number is proportional to the number of magnetic poles on magnetic strip 28 that pass by the Hall effect sensor device 30 during rotation of the wheel as the cart is driven along the course. The remaining conductor wire of cable 35 provides an output signal from the sensor device indicative of direction (forward movement or backward movement of the cart) as described earlier herein. An alternate approach is to send the outputs of the two Hall effect sensors through these two wires directly to the DRN computer for quadrature decoding.

Detailed Description Text (26):
Referring to FIG. 6, the overall system includes a base station 100 typically located in the pro shop or clubhouse of the course. At the base station a course management computer and video monitor receive synchronizing and other data from a GPS receiver 101 which acquires DGPS data transmissions from all GPS satellites such as 102 in LOS. A transceiver 104 provides wireless (e.g., radio frequency) communication with a plurality of carts such as 50, each equipped with an on-board transceiver for that purpose and a receiver of DGPS signals from the satellites for re-calibration of the on-board DR navigation system, preferably at least once for each hole. Each cart also has its own high resolution roof-mounted video display 105 which may include a map of the hole being played replete with location of tee box, hazards, fairway, rough including stands of trees, green and cup, as well as an icon identifying the cart which moves on the display as the cart is driven along the hole. The display also provides an indication of the distance from the cart to the cup and to other objects and features of the particular hole, selectable by the golfer's movement of a cursor on the display screen. A detailed description of such

operations and including the technique for data communications between individual carts and the base station is contained in other applications identified above as incorporated herein by reference.

Detailed Description Text (27):
The depiction of cart 50 in FIG. 6 also illustrates the location of magnetic wheel sensor assembly 24 at the inner wheel well and axle of left front wheel 45. The floated compass and its assembly, preferably mounted in the present embodiment in the roof assembly of the cart at 107 substantially directly above the location of the sensor assembly 24, are fully described in the '962 application, which is duplicated in pertinent part here for the sake of convenience and clarity to the reader. A preferred floated compass sensor is Model No. C-80 manufactured by KVH Industries of Middletown, R.I., to provide measurements of the magnetic heading accurate to one degree. The compass sensor is preferably mounted inside the system roof assembly on the left (driver) front side of the golf cart so that the compass is virtually directly above the top of the left front wheel of the cart. This mounting location minimizes lever arm effects between the wheel sensor and the compass, especially with acceleration compensation. The compass should be located as remotely as possible from any ferrous metal on the cart, to avoid distortion of the magnetic field and the direction of true north, which would degrade the accuracy of the compass readings.

CLAIMS:

1. A system for determining the precise locations of a plurality of golf carts on a golf course in real time as the golf carts are in use during play of the golf course, comprising: a base station including apparatus for wireless communication with each of said carts; each of said carts having a DC electric motor propulsion system, and each of said carts being outfitted with a dead reckoning navigation (DRN) system and a heading detector to fix the location of the respective cart relative to at least one known feature of the golf course to which the respective DRN system has been calibrated; each said DRN system including a magnetic wheel sensor assembly constructed and adapted for detecting speed and forward-backward direction of the cart and for inhibiting electrical and magnetic fields arising from said motor propulsion system and from other sources external to said magnetic wheel sensor assembly from interference with operation of said magnetic wheel sensor assembly; each of said carts further including apparatus for wireless communication with said base station including communication of data derived from said DPN system and said heading detector indicative of location of the respective cart relative to said at least one known feature; and each of said carts having a receiver for receiving differential global positioning system DGPS) signals from earth satellites for re-calibration of the DRN system thereof to said at least one known feature from time to time during each round of play of the golf course, whereby to restore the accuracy of the DRN system upon each re-calibration for relatively accurate determination of real-time location of the respective cart on said golf course.

10. The location determining system of claim 9, wherein said Hall effect sensor is mounted on an axle of said golf cart on which said wheel rotates.

11. The location determining system of claim 10, wherein said Hall effect sensor is mounted above said axle.

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L26: Entry 2 of 2 File: USPT Apr 30, 2002

US-PAT-NO: 6381536
DOCUMENT-IDENTIFIER: US 6381536 B1

TITLE: Apparatus for generating road information from stored digital map database

DATE-ISSUED: April 30, 2002

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PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

Search Selected Search ALL Clear

	PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
☐	5359529	October 1994	Snider	701/207
☐	5508931	April 1996	Snider	701/207

☐	6029111	February 2000	Croyle	701/207
☐	6141619	October 2000	Sekine	701/93
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FOREIGN PATENT DOCUMENTS

FOREIGN-PAT-NO	PUBN-DATE	COUNTRY	US-CL
8-194893	July 1996	JP	

ART-UNIT: 3661

PRIMARY-EXAMINER: Louis-Jacques; Jacques H.

ASSISTANT-EXAMINER: To; Tuan C

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ABSTRACT:

A road information generating apparatus has a stored digitized map database having data identifying roads on a route. The roads of the map database are stored as road segments each having endpoints. The apparatus cancels data defining selected road segments that fall outside of a predetermined window about a predetermined circle approximating a predetermined road curve. The apparatus determines circles each approximating a portion of unselected road segments. The apparatus compares a radius of each of the circles with a predetermined radius value. The apparatus produces road information on acute curve in response to result of comparing the radius of each curve with the predetermined radius value.

14 Claims, 21 Drawing figures

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L26: Entry 2 of 2 File: USPT Apr 30, 2002

DOCUMENT-IDENTIFIER: US 6381536 B1
TITLE: Apparatus for generating road information from stored digital map database

Abstract Text (1):
A road information generating apparatus has a stored digitized map database having data identifying roads on a route. The roads of the map database are stored as road segments each having endpoints. The apparatus cancels data defining selected road segments that fall outside of a predetermined window about a predetermined circle approximating a predetermined road curve. The apparatus determines circles each approximating a portion of unselected road segments. The apparatus compares a radius of each of the circles with a predetermined radius value. The apparatus produces road information on acute curve in response to result of comparing the radius of each curve with the predetermined radius value.

Application Filing Date (1):
20000621

Brief Summary Text (4):
The term "road information" is herein used to mean information on curve of a road that may be used to assist the river of a vehicle to navigate. The term "route" is herein used to mean a course of travel from a current position of a vehicle to a desired destination.

Brief Summary Text (6):
Current vehicle navigation systems may use GPS, such as an electromagnetic wave positioning system, to determine a vehicle's current position. They may use vehicle speed sensor, rate gyro and a reverse gear hookup to "dead reckon" the vehicle's current position from a previously known position. This method of dead reckoning, however, is susceptible to sensor errors, and therefore requires more expensive sensors for accuracy and dependability.

Brief Summary Text (8):
JP-A 8-194893 discloses a technique to use a map database of a navigation system to determine whether or not a curve exists ahead. The map database includes point data, in terms of coordinates, each identifying a trailing endpoint of each of road segments with respect to a direction of travel, and link data each indicative of a length along one of the road segments. The point data do not contain information as to a radius of road curve of each of the road segments. This publication teaches processing the point data to obtain a road curve index, i.e., an azimuth angle, at each of trailing endpoints of the road segments. An initiation of a road curve is determined at a point when the absolute value of the road curve index exceeds a predetermined value. A completion of the curve is determined at a point when subsequently the absolute value of the road curve index drops below the predetermined value. The curve index of a measuring point is determined as an angle between two vectors, namely, a leading vector and a trailing vector. The leading vector terminates at the measuring point and the trailing vector originates at the measuring point. A sampling distance is determined. The leading vector originates at a point before the measuring point by the sampling distance along the road. The

trailing vector terminates at a point ahead the measuring point by the sampling distance along the road. The radius of road curve at the measuring point is determined by calculating the following equation,

Brief Summary Text (10):
R.sub.n is radius of road curve at endpoint n,

Brief Summary Text (11):
L.sub.n is sampling distance at endpoint n, and

Brief Summary Text (12):
.theta..sub.n is road curve index at endpoint n.

Brief Summary Text (13):
The sampling distance L.sub.n is updated by the previous known radius of road curve R.sub.n-1 calculated at the previous measuring point n-1. The endpoints are equidistant along a road at a predetermined distance. The sampling distance L.sub.n results from multiplying an integer with this predetermined distance.

Brief Summary Text (20):
an application unit to implement a circular arc approximation type logic, which, when rendered operable, cancels data defining selected road segments that fall outside of a predetermined window about a predetermined circle approximating a predetermined road curve, determines circles, each approximating a portion of non-selected road segments, compares a radius of each of said circles with a predetermined radius value, and produces road information on acute curve in response to result of said comparing the radius of each of said curves with said predetermined radius value.

Drawing Description Text (2):
FIG. 1 is a general illustration of the various segments in the NAVSTAR GPS system.

Drawing Description Text (19):
FIG. 18 is a graph illustrating the variation of a travelling distance of an automobile until its driver recognizes a curve on road against variation of speed.

Drawing Description Text (20):
FIG. 19 is a graph illustrating the variation of a travelling speed of an automobile as its driver negotiates with a curve against variation of radius of a circle approximating a curve.

Detailed Description Text (3):
Current vehicle navigation systems use GPS to determine a vehicle's current position. Such a GPS system is the Navigation Satellite Timing and Ranging (NAVSTAR) Global Positioning System, which is a space-based satellite radio navigation system developed by the U.S. Department of Defense (DoD). GPS includes NAVSTAR GPS and its successors, Differential GPS (DGPS), or any other electromagnetic wave positioning systems. NAVSTAR GPS receivers provide users with continuous three-dimensional position, velocity, and time data.

Detailed Description Text (4):
NAVSTAR GPS consists of three major segments: Space, Control, and User as illustrated in FIG. 1. The space segment 10 consists of a nominal constellation of 24 operational satellites, which have been placed, in 6 orbital planes above the Earth's surface. The satellites are in circular orbits in an orientation that normally provides a GPS user with a minimum of five satellites in view from any point on Earth at any one time. The satellites broadcast an RF signal that is modulated by a precise ranging signal and a coarse acquisition code ranging signal to provide navigation data.

Detailed Description Text (5):
The navigation data, which is computed and controlled by the GPS control segment 12, includes the satellite's time, its correction and ephemeris parameters, almanacs, and health status for all GPS satellites. From this information, the user computes the precise position and clock offset

Detailed Description Text (6):
The control segment 12 consists of a Master Control Station and a number of monitor stations at various locations around the world. Each monitor station tracks all the GPS satellites in view and passes the signal measurement data back to the master control station. There, computations are performed to determine precise satellite ephemeris and satellite clock errors. The master control station generates the upload of user navigation data from each satellite. This data is subsequently rebroadcast by the satellite as part of its navigation data message.

Detailed Description Text (7):
The user segment 14 is the collection of all GPS receivers and their application support equipment such as antennas and processors. This equipment allows users to receive, decode, and process the information necessary to obtain accurate position, velocity and timing measurements. This data is used by the receiver's support equipment for specific application requirements. GPS supports a wide variety of applications including navigation, surveying, and time transfer.

Detailed Description Text (9):
FIG. 2 illustrates, in block diagram form, an exemplary arrangement of a vehicle navigation system 20 for an automobile 22. The vehicle navigation system 20 uses a GPS antenna 24 to receive the GPS signals. The GPS antenna 24 can be connected to a pre-amplifier 26 to amplify the GPS signals received by the antenna 24. The pre-amplifier 26 is optional, and the GPS antenna 24 can be directly connected to a GPS receiver 28.

Detailed Description Text (10):
The GPS receiver 28 continuously determines geographic position by measuring the ranges (the distance between a satellite with known coordinates in space and the receiver's antenna) of several satellites and computing the geometric intersection of these ranges. To determine a range, the GPS receiver 28 measures the time required for the GPS signal to travel from the satellite to the receiver antenna 24. The timing code generated by each satellite is compared to an identical code generated by the GPS receiver 28. The receiver's code is shifted until it matches the satellite's code. The resulting time shift is multiplied by the speed of light to arrive at the apparent range measurement.

Detailed Description Text (11):
Since the resulting range measurement contains propagation delays due to atmospheric effects, and satellite and receiver clock errors, it is referred to as "pseudorange." Changes in each of these pseudoranges over a short period of time are also measured and processed by the GPS receiver 28. These measurements, referred to as delta range measurements or "delta-pseudoranges," are used to compute velocity. Delta ranges are in meters per second, which are calculated by the GPS receiver 28 from pseudoranges, and the GPS receiver 28 can track the carrier phase of the GPS signals to smooth out the pesudoranges. The velocity and time data is generally computed once a second. If one of the position components is known, such as altitude, only three satellite pseudorange measurements are needed for the GPS receiver 28 to determine its velocity and time. In this case, only three satellites need to be tracked.

Detailed Description Text (12):
The error in the range measurement is dependent on one of two levels of GPS accuracy to which the user has access. PPS is the most accurate, but is reserved

for use by DoD and certain authorized users. SPS is less accurate and intended for general public use. The SPS signal is intentionally degraded to a certain extent by a process known as Selective Availability (SA). SA is used to limit access to the full accuracy of SPS in the interest of U.S. national security. Differential GPS (DGPS) may be used to correct certain bias-like errors in the GPS signals. A Reference Station receiver measures ranges from all visible satellites to its surveyed position. Differences between the measured and estimated ranges are computed and transmitted via radio and other signals to differential equipped receivers/hosts in a local area. Incorporation of these corrections into the range measurements can improve their position accuracy.

Detailed Description Text (13):
As shown in FIG. 2, the GPS receiver 28 provides GPS measurements to an application unit 32. The application unit 32 consists of application processing circuitry 34, such a processor, memory, busses, the application software and related circuitry and interface hardware 36.

Detailed Description Text (14):
The navigation system 20 can include a combination of the features, such as those shown in dashed lines. For example, the navigation system could rely upon information provided by the GPS receiver 28, an accelerometer 38 and map database 42 to propagate vehicle position. According to another aspect, the navigation system 20 can use the accelerometer 38, an odometer 40 and the map database 42. According to other aspect, the navigation system 20 can include a speed sensor 46 and a heading sensor 48, such a gyro, compass or differential odometer.

Detailed Description Text (15):
FIG. 3 shows a block and data flow diagram for the navigation system 20. The GPS receiver 28 provides position information, velocity information, velocity information, pseudoranges and delta pseudoranges to a sensor integrator 50. The sensor integrator 50 uses the velocity information to determine a current position for the vehicle. If GPS velocity information is not available, the sensor integrator 50 can calculate GPS velocity using the available data range measurements to determine a current position for the vehicle. GPS velocity information is derived from a set of delta range measurements. If only a subset of delta range measurements is available, the navigation system 20 can derive GPS velocity information from the subset of delta range measurements. The navigation system uses the GPS position information at start-up as a current position and as a check against the current position. If the current position fails the check, then the GPS position can replace the current position.

Detailed Description Text (16):
If GPS velocity information is not available, the navigation system 20 can obtain information used to propagate the current position from the sensors. The accelerometer 38, which is a multiple axis accelerometer, provides acceleration information for at least two orthogonal axes (lateral, longitudinal and/or vertical) to the application unit 32. The odometer 40 provides information, which can be used in place of the information derived from the accelerometers. Other available information can include the odometer distance and GPS heading, a distance calculation and map heading, the GPS speed information and map heading, gyro heading and longitudinal speed and other variants.

Detailed Description Text (18):
In any event, if GPS is available or not, the sensor integrator 50 provides the current position and a velocity (speed and heading) to a map matching block 52. The map matching block 52 provides road segment information for the road segment that the vehicle is determined to be travelling on, such as heading, and a suggested position. The sensor integrator 50 can update the heading component of the velocity information with the heading provided by the map matching block 52 to update the current position. If the map matching block 52 indicates a good match, then the map

matched position can replace the current position. If not, the sensor integrator 50 propagates the previous position to the current position using the velocity information. As such, the sensor integrator 50 determines the current position and provides the current position to a user interface and/or route guidance block 56.

Detailed Description Text (19):
The map matching block 52 also provides correction data, such as a distance scale factor and/or offset and a turn rate scale factor and/or offset, to a sensor calibration block 54. The sensor integrator 50 also provides correction data to the sensor calibration block 54. The correction data from the sensor integrator 50, however, is based on the GPS information. Thus, accurate correction data based on the GPS information is continuously available to calibrate the sensors 38 (2 or 3 axis accelerometer) as well as other sensors 40, 46 and 48. The correction data from the map matching block 52 may be ignored by the sensor calibration block 54 until a good match is found between the map information and the current position. If a highly accurate match is found by map matching 52, the map matched position is used as a reference point or starting position for position propagation.

Detailed Description Text (22):
The sensor integrator 50 provides the vehicle current position information to an array formation block 62. The map database 42 has a network of roads. The roads of the map database 42 are stored as road segments. Each road segment has endpoints. Each endpoint is provided in geodetic coordinates (latitude, longitude, and altitude). These data are referred to as "point data." The endpoints are connected one after another by lines along road. Each line interconnecting the adjacent two endpoints defining a road segment is provided in length. These data are referred to as "line data." The array formation block 62 collects information at each of endpoints from the map database 42 along route that has been determined from the current position to a desired destination. Each piece of information collected as related to the leading or initiating endpoint of a road segment can be used as a road curve indicative variable. The array formation block 62 arranges collected pieces of information in an array and provides them to a deletion block 64. The deletion block 64 finds an endpoint interconnecting line that is longer than a threshold value and removes an endpoint to which the line is related. This threshold value derives from a predetermined radius of road curve. The other endpoints, which have passed through the deletion block 64, are fed to a decision block 66. The decision block 66 performs approximation of road curve by finding a circle interconnecting three, for example, adjacent endpoints of interconnected road segments, and determining that the road segments have tight curve when a radius of road curve is less than a threshold value. The array formation, deletion and decision blocks 62, 64 and 66 can be incorporated in the application unit 32 of the navigation system 20 (see FIG. 2). Other possibility is that they can be incorporated in an independent application unit that includes a processor composed of a central processor unit (CPU), a random access memory (RAM) and a read only memory (ROM).

Detailed Description Text (23):
FIG. 5 shows a general flow chart illustrating how the road information generating apparatus 60 using the deletion block 64 and the approximation technique in the decision block 66 outputs road information on where on the route tight curve exists. At step 70, the road information generating apparatus 60 inputs the current position. At step 72, the apparatus 60 determines a route from the current position to a desired destination. At step 74, the apparatus 60 uses information from the map database 42 and collects a set of data at each of endpoints of road segments forming a road network on the route and arrange the data sets in an array. Each data set includes an azimuth angle at an endpoint and the length of a line leading from the endpoint to the adjacent endpoint. FIG. 6 shows how the road information generating apparatus 60 obtains, at an endpoint P.sub.n, an azimuth angle .theta..sub.n and the length L.sub.n of a line interconnecting the endpoint P.sub.n and the next adjacent endpoint P.sub.n+1. The array of data sets can be

expressed as,

Detailed Description Text (24):
At the next step 76, the road information generating apparatus 60 determines a threshold value L.sub.th from a predetermined radius of road curve. At step 78, the road information generating apparatus 60 delete the data set at such an endpoint P.sub.n when the length of its line L.sub.n is greater than the threshold value L.sub.th. The deleted data may be stored as a list. At step 80, the road information generating apparatus 60 determines that road segments has tight curve when a radius of a circle approximating the three, for example, adjacent endpoints is less than a threshold value. At step 82, the road information generating apparatus 60 stores the road segments defining endpoints found to have tight curve.

Detailed Description Text (25):
FIGS. 7 and 8 show diagrams how the road information generating apparatus 60 determines the threshold value L.sub.th of the length of a line interconnecting the two adjacent endpoints. FIG. 7 shows that there is an error .delta., between the endpoint interconnecting circular and the endpoint interconnecting line, which grows as the length L.sub.n of the line becomes longer and longer. It clearly indicates that if the length of a line exceeds a predetermined value, it no longer represent a road segment having a road curve radius R. This predetermined value is the threshold value L.sub.th.

Detailed Description Text (26):
FIG. 8 shows how to determine the threshold value L.sub.th from the threshold value R of road curve radius and the error .delta.. The following relation holds,]

Detailed Description Text (28):
If, for example, the error .delta.=2 m and the threshold value of road curve radius R=250 m, then

Detailed Description Text (29):
This equation (3) clearly indicates that if the length of a line exceeds 63.1 m, a road segment, which this line represents, could have a road curve radius greater than the threshold value of road curve radius 250 m. The equation (2) shows that the error .delta. and the threshold value of road curve radius R determine the threshold value L.sub.th of a line.

Detailed Description Text (30):
The error .delta. and the road curve radius threshold valve R can be kept invariable over the entirety of route, over which the vehicle may move. However, they may be varied in response to variations in width or type of road.

Detailed Description Text (33):
The content of the buffer is composed of point data of such endpoints whose line length are less than or equal to the threshold value L.sub.th. The road information generating apparatus 60 performs approximation of road curve by finding a circular arc interconnecting three, for example, adjacent endpoints of interconnected road segments, and determining that the road segments have tight curve when a radius of road curve is less than a threshold value, In determining tight curve, the deleted endpoints are not considered because road curve around each of such endpoints is gradual or near straightforward and cannot be considered as being tight. Road configuration around each of the deleted endpoints can be considered as gradual curve approximating a straightforward road.

Detailed Description Text (34):
With regard to the operation at the decision block 66 (see FIG. 4), if the array of endpoints on a route, each of which has a line length less than the threshold value L.sub.th, are expressed by P.sub.0, P.sub.1, . . . , P.sub.n, the road information

generating apparatus 60 can find a circle interconnecting any three consecutive endpoints P.sub.n-1, P.sub.n, P.sub.n+1. The radius of this circle can be determined based on the coordinates of the three endpoints. This radius can be considered as a road curve radius of road segments defined by the three endpoints. If this curve radius is less than the threshold value, the road information generating apparatus 60 determines that these road segments have acute curve.

Detailed Description Text (35):
In the case where more than three consecutive endpoints are used for calculation, a radius of road curve can be obtained by finding a circular arc that minimizes the root-sum-square of errors .delta..

Detailed Description Text (36):
In another embodiment, the road information generating apparatus 60 calculates sum of azimuth angles at endpoints defining road segments and sum of lengths of lines interconnecting the endpoints to determine a ratio between the sum of azimuth angles and the sum of the line lengths. This ratio is named an azimuth angle per unit line length. The road information generating apparatus 60 determines a reference azimuth angle per unit line length of a standard circle having a radius to be used as a threshold radius value. The road information generating apparatus 60 can compare the azimuth angle per unit line length with the reference azimuth angle per unit line length. In response to the result of this comparison, the road information generating apparatus 60 determines that the road segments have acute curve when the azimuth angle per unit line length is greater than the reference azimuth angle per unit line length.

Detailed Description Text (37):
FIG. 10 shows the case where the road information generating apparatus 60 may disregard some of consecutively arranged endpoints P.sub.0 to P.sub.6 in determining whether or not road segments have acute curve. In this case, the road information generating apparatus 60 can disregard two endpoints P.sub.2 and P.sub.4 because they add to little information needed for creating the configuration of the road segments.

Detailed Description Text (39):
FIG. 12 shows a diagram illustrating how the road information generating apparatus 60 can shift an array of endpoints by two if four consecutive endpoints are examined for determination of the presence of acute curve. The lower half of FIG. 12 clearly indicates that the road information generating apparatus can examine all of the endpoints because there is overlap between the adjacent two ranges of covering the endpoints. In general, fit the number n of endpoints to be examined is more than three, the road information generating apparatus can determine the presence of acute curve by shifting the array of endpoints by at most (n-2). The number of frequency of conducting process to determine the presence of acute curve drops.

Detailed Description Text (40):
The road information generating apparatus 60 can vary the number of endpoints, a set of sampled endpoints and the presence or absence of disregarding some of the endpoints in response to width of road, types or kinds of road and a threshold road curve value.

Detailed Description Text (41):
From the preceding description, it is apparent that since such endpoints, each having a considerably long line length, have been deleted, the precision of determining as to the presence of acute curve is improved or enhanced.

Detailed Description Text (47):
Accordingly, if the current azimuth angle .theta..sub.n at the endpoint P.sub.n is less than this angle .theta., a circle interconnecting these three endpoints

P.sub.n-1, P.sub.n and P.sub.n+1 has a radius greater than R. In this case, it is theoretically true that the road segments defined by these endpoints always take a curve less acute than the curve of the circle having the radius R.

Detailed Description Text (50):
Accordingly, the road information generating apparatus 60 determines that the road segments defined by the endpoints P.sub.n-1, P.sub.n and P.sub.n+1 have less acute curve than the curve of the reference circle having the radius R when the azimuth angle .theta..sub.n has the following relation

Detailed Description Text (56):
Referring to FIGS. 15 to 18, description on a third preferred implementation of a road information generating apparatus 60A is made. In each of the preceding embodiments the decision block 66 incorporates circular arc approximation type logic to determine whether or not acute curve is present. The road information generating apparatus 60A has a first decision block 104 and a second decision block 106. A selector 108 is provided to render appropriate one of the first and second decision blocks 104 and 106 operable. The second decision block 106 incorporates the circular arc approximation type logic to determine whether or not acute angle curve is present. The first decision block 104 incorporates azimuth angle type logic, which will be described later in connection with FIG. 17, to determine whether or not acute curve is present.

Detailed Description Text (58):
The road information generating apparatus 60A uses the circular arc approximation type logic when travelling on highways and uses the azimuth angle type logic under the other travelling circumstance. The term "highways" herein used does not include a toll road network in Tokyo, called "Shuto Express Way" because it is narrow and has acute curves. The term "highways", however, includes such major roads, each having a wide width without any acute curve and toll roads even if they are not labeled as express ways. The database 42 provides enough information on each of roads to the selector 108.

Detailed Description Text (59):
Output indicative of results of the circular arc approximation type logic conduced at the first decision block and output indicative of result of the azimuth angle type logic conducted at the second decision logic are selectively applied to an engine controller 110 for an engine 114 and also to a transmission controller 112 for an automatic transmission. When acute curve is present, the engine controller 110 and the transmission controller 112 cooperate with each other to lower driving force before entering the acute curve.

Detailed Description Text (61):
FIG. 17 is a flow chart illustrating the azimuth angle type logic. At step 128, the road information generating apparatus 60A inputs an azimuth angle .theta..sub.n from the map database 42. At interrogation step 130, the road information generating apparatus 60A determines whether or not .theta..sub.n is less than an upper limit value .theta..sub.max. The setting is such that the upper limit value .theta..sub.max is approximately 15.degree.. If, at step 130, .theta..sub.n is less than the upper limit value .theta..sub.max, the road information generating apparatus 60A determines, at interrogation step 132, whether or not .theta..sub.n is greater than a lower limit value .theta..sub.min. The setting is such that the lower limit value .theta..sub.min is approximately 10.degree.. Setting the upper and lower limit values .theta..sub.max and .theta..sub.min at 15.degree. and 10.degree. has proved to provide curve detection in good match to driver's perception. Naturally, the upper and lower limit values .theta..sub.max and .theta..sub.min may take any appropriate values depending upon map database, operation state and type of road.

Detailed Description Text (62):

If, at step 130, the azimuth angle .theta..sub.n is not less than the upper limit value .theta..sub.max, the road information generating apparatus 60A sets, at step 134, curve flag F.sub.CURV equal to ON level. This is apparently the case where the road has acute curve. If, at step 132, the azimuth angle .theta..sub.n is not greater 30 than the lower limit value .theta..sub.min, the road information generating apparatus 60A resets, at step 136, curve flag F.sub.CURV equal to OFF level. This is apparently the case where the road is straight.

Detailed Description Text (63):
If, at step 132, the azimuth angle .theta..sub.n is greater than the lower limit value .theta..sub.min, the road information generating apparatus 60A performs a table look-up operation, at step 138, of FIG. 18 using vehicle sped V to obtain a preset value L.sub.th. The fully drawn curve in FIG. 18 shows the variation of a travelling distance of an automobile vehicle until its driver recognizes a curve on the road against variation of travelling speed of the vehicle. Apparently, the travelling distance is not longer than 20 m at speeds below about 40 km/h. At speeds higher than about 40 km/h, the travelling distance increases as speed increases. The variation of this travelling distance is mapped as the preset value L.sub.th against variation of vehicle speed V.

Detailed Description Text (65):
where: R.sub.th is the lower limit of radii of curves which an automobile can pass through without any considerable drop in travelling speed.

Detailed Description Text (66):
The radius of curve R.sub.th is given by the fully drawn curve in FIG. 19, The fully drawn line in FIG. 19 illustrates the variation of speed of an automobile as it passes through a road curve against the radii of circles approximating different road curves. Apparently, the travelling speed of the automobile decreases as the radius decreases. There is a radius around which the travelling speed drops considerably. This radius is set as the above-mentioned radius R.sub.th.

Detailed Description Text (68):
At interrogation step 144, the road information generating apparatus 60A determines whether or not the sum .SIGMA. is less than the preset value .SIGMA..sub.th. If this is not the case, the road information generating apparatus 60A sets the curve flag F.sub.CURV equal to ON level. If this is the case, the road information generating apparatus 60A resets the curve flag F.sub.CURV equal to OFF level.

Detailed Description Text (70):
If, at an endpoint measured, the selector 108A provides an indication of absence of any acute curve and the driver depresses the brake pedal immediately after release of the accelerator pedal, the driver perceives acute curve ahead on the road, the selection by the selector 108A is an error.

Detailed Description Text (71):
If, at an endpoint measured, the selector 108A provides an indication of the presence of acute curve and the driver has depressed the accelerator pedal immediately after release of the accelerator pedal, the selection by the selector 108A is an error.

Detailed Description Text (76):
If the selection at step 144 indicates the absence of any acute curve and the driver depresses the brake pedal immediately after release of the accelerator pedal, the road information generating apparatus 60B recognizes the occurrence of an error because the driver has perceived the presence of acute curve.

Detailed Description Text (77):
If the selection at step 144 indicates the presence of acute curve and the driver has depressed the accelerator pedal immediately after release of the accelerator

pedal, the road information generating apparatus 60B recognizes the occurrence of an error because the driver has perceived the absence of acute curve.

CLAIMS:

1. An apparatus for generating road information on a route over which a vehicle may move, the apparatus comprising:

a stored map database having data identifying roads on the route, said roads of said stored map database being stored as road segments each having endpoints; and

an application unit to implement a circular arc approximation type logic, which, when rendered operable, canels data defining selected road segments that fall outside of a predetermined window about a predetermined circle approximating a predetermined road curve, determines circles, each approximating a portion of non-selected road segments, compares a radius of each of said circles with a predetermined radius value, and produces road information on acute curve in response to result of said comparing the radius of each of said curves with said predetermined radius value.

2. The apparatus as claimed in claim 1, wherein said application unit is operative to generate a train of data sets for said road segments, respectively, each set including a trailing one of said endpoints defining one of said road segments, and a length of a link interconnecting said trailing one endpoint and a leading one of said endpoints defining said one road segment, wherein said application unit is operative to compare the length of each of said links with a predetermined value, and wherein said application unit is operative to consider whether or not each of said road segments follows a course that falls in said predetermined narrow window in response to the corresponding one of results of said comparison of the length of each of said links with said predetermined value.

3. The apparatus as claimed in claim 1, wherein said application unit is operative to generate a train of data sets for said road segments, respectively, each set including a trailing one of said endpoints defining one of said road segments, and an azimuth angle defined between a first link interconnecting said trailing one endpoint and a leading one of said endpoints defining said one road segment and a second link interconnecting said trailing one endpoint and a trailing one of endpoints defining the adjacent road segment succeeding said one road segment, wherein said application unit is operative to compare each of said azimuth angles with a predetermined value, and wherein said application unit is operative to consider whether or not each of said road segments follows a course that falls in said predetermined narrow window in response to the corresponding one of results of said comparison of each of said azimuth angles with said predetermined value.

4. The apparatus as claimed in claim 1, wherein said application unit is operative to generate a train of data sets for said road segments, respectively, each set including a trailing one of said endpoints defining one of said road segments, a length of a first link interconnecting said trailing one endpoint and a leading one of said endpoints defining said one road segment, and an azimuth angle defined between said first link and a second link interconnecting said trailing one endpoint and a trailing one of endpoints defining the adjacent road segment succeeding said one road segment, wherein said application unit is operative to compare the length of each of said links with a predetermined length value, wherein said application unit is operative to compare each of said azimuth angles with a predetermined angle value, and wherein said application unit is operative to consider whether or not each of said road segments follows a course that falls in said predetermined narrow window in response to a predetermined logic including the corresponding one of results of said comparison of the length of each of said links with said predetermined length value and the corresponding one of results of said comparison of each of the azimuth angles with said predetermined angle value.

5. The apparatus as claimed in claim 1,

wherein said application unit is operative to generate a train of data sets for said road segments, respectively, each set including a trailing one of said endpoints defining one of said road segments, a length of a first link interconnecting said trailing one endpoint and a leading one of said endpoints defining said one road segment, and an azimuth angle defined between said first link and a second link interconnecting said trailing one endpoint and a trailing one of endpoints defining the adjacent road segment succeeding said one road segment,

wherein said application unit is operative to implement an azimuth angle type logic, which, when rendered operable, calculates a sum of a plurality of said azimuth angles of a desired one of said endpoints and some of the other of said endpoints located within a predetermined distance from said desired one endpoint along the route, compares said calculated sum with a predetermined sum of angles, and produces information indicative of existence of a curved road in response to result of said comparing said calculated sum with said predetermined sum of angles, and

wherein said application unit is operative to render one of said circular arc approximation type logic and said azimuth angle type logic operable and the other inoperable in response to at least road information stored in said stored map database and operator manipulated parameter information.

7. The apparatus as claimed in claim 5, wherein said application unit is operative to compare the corresponding one of said azimuth angles to said desired one of said endpoints, and to produce information indicative of existence of a curved road when the corresponding one azimuth angle is greater than a predetermined maximum angle value.

8. The apparatus as claimed in claim 5, including a vehicle speed sensor to generate a vehicle speed signal indicative of traveling speed of the vehicle,

wherein said predetermined distance is determined as a function of said vehicle speed signal, and said predetermined sum of angles is determined as a function of said predetermined distance.

12. An apparatus for generating road information on a route over which a vehicle may move, the apparatus comprising:

a stored map database having data identifying roads on the route, said roads of said stored map database being stored as road segments each having endpoints; and

means operable to input data from said stored map database, said means being operative to cancel data defining selected road segments that fall outside of a predetermined window about a predetermined circle that approximates a predetermined road curve, to determine circles, each approximating a portion of unselected road segments, to compare a radius of each of said circles with a predetermined radius value, and to produce road information on acute curve in response to result of said comparing the radius of each of said curves with said predetermined radius value.

13. A method of generating road information on a route over which a vehicle may move, the method comprising:

preparing a digitized map database having data identifying roads on the route, said roads of said map database being stored as road segments each having endpoints;

canceling data defining selected road segments that fall outside of a predetermined

window about a predetermined circle that approximates a predetermined road curve;

determining circles, each approximating unselected road segments;

comparing a radius of each said circles with a predetermined radius value; and

producing road information on acute curve in response to result of said comparing the radius of each of said curves with said predetermined radius value.

14. An apparatus for generating road information on a route over which a vehicle may move, the method comprising:

means for storing a digitized map database having data identifying roads on the route, said roads of said map database being stored as road segments each having endpoints;

means for canceling data defining selected road segments that fall outside of a predetermined window about a predetermined circle that approximates a predetermined road curve;

means for determining circles, each approximating a portion of unselected road segments;

means for comparing a radius of each of said circles with a predetermined radius value; and

means for producing road information on acute curve in response to result of said comparing the radius of each of said curves with said predetermined radius value.

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US-PAT-NO: 6230083
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TITLE: Road shape predicting method and vehicle controlling method

DATE-ISSUED: May 8, 2001

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U.S. PATENT DOCUMENTS

Search Selected Search ALL Clear

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10-283594	October 1998	JP	

ART-UNIT: 361

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ABSTRACT:

A road shape predicting method includes the steps of: selecting three positions of positions of a plurality of nodes constituting road map data and an own vehicle position on a road; and predicting the road shape on the basis of a crossing angle formed by a link connecting a first position and a second position of the selected three positions and another link connecting the second and a third position thereof, and a link length between the second and the third positions. In case that the link length between the second and the third positions is not larger than a reference link length set in accordance with the crossing angle, the third position is excluded, and the position of a node further forward is adopted in place of the third position, to thereby predict the road shape.

6 Claims, 11 Drawing figures

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L29: Entry 3 of 4 File: USPT May 8, 2001

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TITLE: Road shape predicting method and vehicle controlling method

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Brief Summary Text (5):
Such a road shape predicting method and a vehicle controlling method were proposed in U.S. patent application Ser. No. 09/056,244 by the applicant of this invention. As seen from FIG. 4, they use coordinates of a larger number of nodes N.sub.N (N.sub.N =N.sub.0, N.sub.1, N.sub.2, N.sub.3, . . .) set at prescribed intervals on a road as road map data. On the basis of a link length L.sub.N which is defined as a distance between adjacent nodes N.sub.N and N.sub.N+1, and a crossing angle .theta..sub.N formed by a certain link N.sub.N-1 N.sub.N and another link N.sub.N N.sub.N+1 located forward, a passing state decision quantity (vehicle cornering amount) .theta..sub.N /L.sub.N at each node is computed. The passable speed at the node N.sub.N computed on the basis of the passing state decision quantity .theta..sub.N /L.sub.N is compared with the passage predicting speed at the node N.sub.N through which an own vehicle passes. If it is decided that the passage is difficult, a warning is given to a driver or automatic speed reduction is made. The above passing state decision quantity .theta..sub.N /L.sub.N corresponds to a change quantity in the azimuth angle of a vehicle for a moving distance thereof. Its large value indicates that the road is curved, whereas its small value indicates that the road is straight.

Brief Summary Text (6):
Where there are three nodes N.sub.0, N.sub.1, N.sub.2, on a straight road as shown in FIG. 9, if the positions of the nodes are deviated from the inherent N.sub.0, N.sub.1, N.sub.2, to N.sub.0 ', N.sub.1 ', N.sub.2 ', owing to an error in the road map data, at the node N.sub.1, the passing state quantity .theta.1/L1 which should not be essentially produced is produced. In this case, if the link length L.sub.1 between N.sub.1 and N.sub.2 is sufficiently large, the passing state decision quantity .theta..sub.1 /L.sub.1 is relatively small so that the road shape is decided to be a gentle curve approximately to the straight road. Thus, no hitch occurs. On the other hand, if the link length L.sub.1 between N.sub.1 and N.sub.2 is small, the passing state quantity .theta..sub.1 /L.sub.1 is fairly large so that the road shape which should be actually straight is decided to be erroneously curve.

Brief Summary Text (17):
In the embodiment, the above coefficient A is set in a range from 0.2 to 0.5. Therefore, it can be suitably set in a range satisfying 0<A<1 in accordance with the accuracy of the road map data. The upper limit of the sag d is defined as the upper limit of a distance between a link connecting two adjacent nodes and an actual road. In the embodiment, it is actually 2.5 m-6 m.

Brief Summary Text (19):
In this configuration, where the position of the node further forward is located forward to exceed a prescribed length from the second position, the position of the node further forward is not adopted. For this reason, it is possible to avoid

adopting the node not presenting on the same curve to thereby prevent reduction in the predicting accuracy of the road shape.

Detailed Description Text (3):
As seen from FIG. 1, a passage deciding apparatus mounted on a vehicle includes a map information output device M1, an own vehicle position detecting device M2, a curve section deciding device M3, a passing state decision quantity computing device M4, a passable speed computing device M5, a vehicle speed detecting device M6, a passage predicting speed computing device M7, a passage deciding device M8, a warning device M9 serving as a vehicle controlling device and a vehicle speed adjusting device M10 serving as the vehicle controlling device. The curve section deciding device M3 and passing state decision quantity computing device M4 constitute a road shape deciding device M11.

Detailed Description Text (4):
The map information output device M1 and own vehicle position detecting device M2 are loaded in a known navigation apparatus for a motor vehicle. The map information output device M1 reads out road map data in a prescribed region which are previously stored in an IC card, CD-ROM, storage-rewritable MO (magneto-optic disk), etc. The own vehicle position detecting device M2 superposes the own vehicle position data received from a GPS antenna on the above road map data to detect an own vehicle position P. The road map data are constructed by the coordinates of a large number of nodes N.sub.N set at prescribed intervals.

Detailed Description Text (5):
On the basis of the road map data and own vehicle position P, the curve section deciding device M3 decides whether the node N.sub.N forward of the own vehicle position P is on a curve road or a straight road. The passing state decision quantity computing device M4 computes a passing state decision quantity .theta..sub.N /L.sub.N which is an index for deciding whether or not the vehicle can pass the curve road.

Detailed Description Text (6):
On the basis of the passing state decision quantity .theta..sub.N /L.sub.N and a setting boundary horizontal acceleration G (or setting boundary yaw rate YR) preset to the degree that a driver can pass the curve safely, the passable speed deciding device M5 computes a passable speed V.sub.maxN that is a maximum vehicle speed permitting the vehicle to pass the node N.sub.N safely.

Detailed Description Text (9):
Assuming that a driver spontaneously starts braking at the own vehicle position P to pass a forward curve, the reference deceleration .beta. occurring owing to the braking is preset. The estimating section can be determined on the basis of Vt-(.beta.t.sup.2 /2) representing a distance when the vehicle runs within the prescribed time t. The start of the investigating section is set at the end of the estimating section, and the end thereof is set at the position where the vehicle decelerating at the reference decelerating speed .beta. stops, i.e. at the position far from the own vehicle by a distance V.sup.2 /2.beta..

Detailed Description Text (15):
As seen from FIG. 5, it is assumed that when a plurality of nodes N . . . are present on an arc-shaped road, the length of the link connecting two adjacent nodes N and N is L, the distance between the link and the road is a sag d, the curvature of the road is R, and the center angle of the arc between the two nodes N and N is .theta.. Now the sag will be previously explained. As seen from FIGS. 6A and 6B, it is assumed that an arc-shaped road is represented as a collection of a plurality of nodes N . . . , and the link length L between the adjacent nodes N and N is constant. In this case, as shown in FIG. 6A, when the curvature of the road is large, the maximum value d of the difference between the link connecting the adjacent nodes N and N and the actual road is relatively small. On the other hand,

as shown in FIG. 6B, when the former is small, the latter is relatively large. This attenuates the accuracy of the road map data. Such an inconvenience can be avoided by making the adjacent nodes nearer to each other so that the link length L can be shortened. However, this excessively increases the number of the nodes, thereby boosting the cost for forming the road map data.

Detailed Description Text (16):
Therefore, when the road map data are formed, the positions of the nodes are determined so that the sag d between the link connecting the adjacent nodes N and N and the actual road does not exceed a prescribed upper limit. As a result, as seen from FIG. 7A, when the curvature of the road is large, in order that the distance between the link and the road does not exceed the prescribed upper limit of the sag d, the link length L is relatively long. Inversely, as seen from FIG. 7B, when the curvature of the road is small, in order that the distance between the link and the road does not exceed the prescribed upper limit of the sag d, the link length L is relatively short. In this way, by setting the positions of the nodes N . . . while the sag d is kept at the value not larger than the upper limit (generally, 2.5 m-6 m), the required accuracy of the road map data can be assured and the excessive increase of the number of the nodes can be avoided.

Detailed Description Text (36):
The maximum link length in the above Equation (1), L.sub.max =2d/tan .theta./4 is the maximum value of the link length L when the nodes N.sub.N-1, N, N.sub.N+1, are present on the same curve. This is because the sag d on the right side in Equation (1) is the upper limit of the distance between the link and the road, and if the distance is smaller than the upper limit of the sag d, the link length L is smaller than the maximum link length L.sub.max in Equation (1). Therefore, where the link length L exceeds the value in Equation (1), i.e. L>2d/tan .theta./4 is established, the nodes N.sub.N-1, N, N.sub.N+1 are not present on the same curve.

Detailed Description Text (40):
Thus, in step S6, if the link length L.sub.N at the reference node N.sub.N is not larger than the reference link length L.sub.refN, as seen from FIG. 8, in step S7, the node N.sub.N+1 forward of the reference node N.sub.N is not adopted. After the node N.sub.N+2 further forward is newly selected, the processing in steps S4-S6 is repeated on the basis of three node N.sub.N-1, N.sub.N and N.sub.N+2. As a result, in step S6, if the link length L.sub.N exceeds the reference link length L.sub.refN, and is shorter than the maximum link length L.sub.maxN, in step S8, the passing state decision quantity .theta..sub.N /L.sub.N is computed by dividing the crossing angle .theta..sub.N by the link length L.sub.N. Under the limitation by the above maximum link length L.sub.maxN, adoption of the node N.sub.N+2 which exceeds the maximum link length L.sub.maxN, i.e. node N.sub.N+2 not present on the same curve can be avoided.

Detailed Description Text (49):
It is seen from Equation (13) that if the setting boundary horizontal acceleration G permitted when the vehicle passes the curve is defined, the passable speed V.sub.maxN when the vehicle passes the curve can be acquired by the setting boundary horizontal acceleration G and the passing state decision quantity .theta..sub.N /L.sub.N. The above passable speed V.sub.maxN is the highest vehicle speed at which the vehicle can pass while horizontal acceleration of the vehicle does not exceed the setting boundary horizontal acceleration G.

Detailed Description Text (50):
On the other hand, in step SA10, assuming that the vehicle has reduced the speed at the reference deceleration .beta. from the own vehicle position P and the distance from the own vehicle position P to the node N.sub.N is S.sub.N, the passage predicting speed V.sub.N at the node N.sub.N can be computed by

Detailed Description Text (52):

In step S11, the passage predicting speed V.sub.N is compared with the passable speed V.sub.maxN. If V.sub.N.ltoreq.V.sub.maxN, it is decided that the vehicle can pass the node N.sub.N. If V.sub.N >V.sub.maxN, it is decided that the vehicle is difficult to pass the node N.sub.N. In this case, in step S12, in order that the driver is urged to reduce the vehicle speed, the warning device M9 is operated, and also in order to reduce the vehicle speed automatically, the vehicle speed adjusting device 10 is operated. Thus, the spontaneous braking by the driver and automatic speed reduction are done to reduce the vehicle speed so that the vehicle can surely pass the curve.

Detailed Description Text (58):
Moreover, where the position of the node further forward is located forward to exceed a prescribed length from the second position, the position of the node further forward is not adopted. For this reason, it is possible to avoid adopting the node not presenting on the same curve, to thereby prevent reduction in the predicting accuracy of the road shape.

CLAIMS:

5. A road shape predicting method according to claim 1, wherein the positions of the plurality of nodes are decided so that a sag being a distance between the link connecting the adjacent nodes and the actual road is not more than a preset upper limit thereof.

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TITLE: Wheel diameter calibration system for vehicle slip/slide control

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APPL-NO: 09/ 118875 [PALM]

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US-CL-CURRENT: 702/96; 180/209, 701/20, 701/82

FIELD-OF-SEARCH: 105/444, 105/96, 180/209, 702/96, 701/19, 701/20, 701/82, 701/88, 701/89, 701/91

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

Search Selected Search ALL Clear

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
3715572	February 1973	Bennett	701/300
4243927	January 1981	D'Atre	318/803
4347569	August 1982	Allen et al.	701/82
4896090	January 1990	Balek et al.	318/52
5740547	April 1998	Kull et al.	701/19

FOREIGN PATENT DOCUMENTS

FOREIGN-PAT-NO	PUBN-DATE	COUNTRY	US-CL
364088	April 1990	EP	

OTHER PUBLICATIONS

"Inverter-Induction Motor Drive For Transit Cars," Plunkett, Plette; IEEE Transactions on Industry Applications, vol. 1A-13, Jan./Feb. 1977, pp. 26-37.

ART-UNIT: 286

PRIMARY-EXAMINER: Noland; Thomas P.

ATTY-AGENT-FIRM: Breedlove; Jill Beuss; James

ABSTRACT:

A method and apparatus for wheel diameter calibration in a vehicle of the type having a plurality of independently powered wheel-axle sets which can be implemented as a forced calibration while the vehicle is in either a tractive effort or an electrical braking mode. The process includes the steps of determining if vehicle tractive effort would be effected if one wheel-axle set were disabled and, if not, selectively disabling one of the wheel-axle sets, calculating vehicle speed from a present value of wheel diameter for the disabled axle and wheel revolutions per unit time, establishing a true value of vehicle speed from an independent measurement, computing the error between calculated vehicle speed and the true value of vehicle speed, and adjusting the present value of wheel diameter so as to minimize the computed speed error.

7 Claims, 3 Drawing figures

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L6: Entry 2 of 2 File: USPT Nov 14, 2000

DOCUMENT-IDENTIFIER: US 6148269 A
TITLE: Wheel diameter calibration system for vehicle slip/slide control

Brief Summary Text (7):
The need for wheel diameter calibration has been recognized in the art. Typically, a locomotive is provided with an auxiliary ground speed sensor such as a radar unit (similar to the type used by police for monitoring automobile speed) or a satellite sensor (generally referred to as global position sensor or GPS). The ground speed signal from one of these sensors is compared to the speed determined from the motor shaft RPM sensor value and any error is corrected by adjusting the calculated value of wheel diameter. One problem with the prior art systems is that the comparison or calibration could only be performed when the locomotive was in a coast mode, i.e, the traction motors were not energized for either powering or braking of the locomotive. Further, it was generally necessary for the locomotive to be in such a coast mode for an extended, continuous time in order to complete the calibration. However, there are many instances in which the opportunity to operate a locomotive for an extended period in a coast mode is simply impractical. Accordingly, it would be advantageous to provide a wheel diameter calibration system which does not require coast mode operation and which does not require an extended, continuous time to achieve calibration.

Brief Summary Text (9):
The present invention is implemented in one form in which a wheel diameter calibration system for a traction vehicle having a plurality of independently powered wheel-axle sets, such as a locomotive, which system allows wheel diameter to be calibrated while the vehicle is in either a tractive effort or electrical braking mode of operation. In the illustrative system, calibration of each wheel-axle set is accomplished by systematically removing power from each wheel-axle set to place that wheel-axle set in a coast mode. The vehicle control initially determines whether a calibration is needed by comparing vehicle velocity as determined by an independent sensor, such as a radar or GPS sensor, to vehicle velocity as determined from a calculation of vehicle speed based upon wheel rotational speed and wheel diameter. If the velocities differ by more than some minimum value, a forced calibration mode is entered. In the forced calibration mode, the control determines first if vehicle tractive effort would be effected if one wheel-axle set were disabled. If not, the one wheel-axle set is disabled, with the commanded tractive effort being distributed over the remaining powered wheel-axle sets. The control thereafter integrates the velocity difference or error while continuously re-computing the error wherein the integrated error value becomes the value of wheel diameter. The control can interrupt the calibration process whenever the disabled wheel-axle set is needed to meet tractive effort requirements. During any interruption in calibration, the last computed value of wheel diameter is maintained so that future calibrations start from the last value thereby allowing calibration to be performed in discontinuous, piecemeal fashion. The control can also accelerate the integration process to perform faster calibration by varying the velocity error signal magnitude by multiplying the error signal by a selectable factor.

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L6: Entry 1 of 2 File: USPT Sep 3, 2002

US-PAT-NO: 6446005
DOCUMENT-IDENTIFIER: US 6446005 B1

TITLE: Magnetic wheel sensor for vehicle navigation system

DATE-ISSUED: September 3, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
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ASSIGNEE-INFORMATION:

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APPL-NO: 09/ 373556 [PALM]
DATE FILED: August 13, 1999

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US-CL-ISSUED: 701/215; 701/216, 701/217, 701/213, 342/357, 342/106, 342/107, 342/137, 342/457, 180/167, 180/168
US-CL-CURRENT: 701/215; 180/167, 180/168, 342/106, 342/107, 342/137, 342/457, 701/213, 701/216, 701/217

FIELD-OF-SEARCH: 701/215, 701/216, 701/217, 701/213, 701/214, 180/168, 180/167, 377/24.1, 342/357, 342/357.14, 342/107, 342/106, 342/108, 342/457, 342/451, 342/463, 473/407, 473/409, 473/137, 473/169

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

Search Selected Search ALL Clear

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
4109186	August 1978	Farque	318/587
4480310	October 1984	Alvarez	364/450
4887281	December 1989	Swanson	377/24.1
5600113	February 1997	Ewers	235/95R

☐	5878369	March 1999	Rudow et al.	701/215
☐	5938704	August 1999	Torii	701/23
☐	5944132	August 1999	Davies et al.	180/168
☐	6024655	February 2000	Coffee	473/407

ART-UNIT: 3661

PRIMARY-EXAMINER: Cuchlinski, Jr.; William A.

ASSISTANT-EXAMINER: To; Tuan C

ATTY-AGENT-FIRM: Blank Rome Comisky & McCauley LLP

ABSTRACT:

A system is disclosed for determining precise locations of the golf carts on a golf course in real time as the carts are in use during play of the course. Each cart is outfitted with a dead reckoning navigation (DRN) system for determining speed and direction, and a compass for determining heading of the cart during play. With these parameters and a known origin of the cart to which the DRN system has been calibrated, such as location of a tee box, the location of the cart relative to a known feature of the course such as a cup or hazard may be calculated. The DRN system uses a magnetic wheel sensor assembly having a magnetic strip with spaced alternating opposite magnetic poles affixed to the rim of an inside wheel well or mounting fixture therefor of the cart, mounted to confront a Hall effect sensor. During rotation of the wheel and the strip when the cart is moving, the sensor detects passage of the alternating poles, to measure speed and forward or backward direction of the cart. A compass determines heading of the cart. The DRN system allows operation on courses where GPS-based systems cannot maintain LOS, and is periodically calibrated by a known signal, such as a DGPS signal.

16 Claims, 13 Drawing figures

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L3: Entry 1 of 1 File: USPT Sep 3, 2002

DOCUMENT-IDENTIFIER: US 6446005 B1
TITLE: Magnetic wheel sensor for vehicle navigation system

Detailed Description Text (29):
A floated compass/front wheel sensor system using the magnetic wheel sensor of the present invention is shown in block diagrammatic form in FIG. 8. The DR sensors are the floated magnetic compass 63 and magnetic wheel sensor 64. The outputs of both sensors (.psi..sub.m for 63 and a pulse stream and level indicative of wheel speed and direction for 64) are delivered to DR navigation algorithms section 65 following initial processing. Output .psi..sub.m is subjected to low pass filtering at 66, and the filtered information derived from the compass sensor output is applied, together with a factor .omega..sub.m related to rate of change of heading derived at 67 from the filtered output and a factor Z.sup.-1 which is an inverse of the residual measurement, a factor .beta..sub.i representing the Earth's magnetic inclination, and inputs derived in similar fashion from the processed output of magnetic wheel sensor 64, relating to wheel speed V.sup.w and wheel acceleration .alpha., to develop a compass tilt estimate correction factor .DELTA..psi. at 68. This correction factor is then applied at 69 to the processed output from the compass sensor 63 to compensate for tilt error.

Detailed Description Text (30):
The resulting data is applied to a compass correction table at 71 and is also added to a factor .beta..sub.d representing the Earth's magnetic declination at 70. The compass correction table (a lookup table) also receives an input of compass corrections from a DGPS/DR calibration which utilizes the differential GPS calibration to restore the accuracy of the dead reckoning navigation system. The table 71 correction .delta..psi..sub.1 is added to the output of 70 at 72 and the result is applied to a table calculator 74 along with information derived from the magnetic wheel sensor output processing path.

Detailed Description Text (31):
In the latter path, the output of magnetic wheel sensor 64 is subjected to application of a wheel scale factor error correction Sf.sub.w from the DGPS/DR calibration at 75, to compensate an error that increases with distance traveled over time. The resulting output undergoes processing similar to that provided in the compass sensor path, as described above, so that the pair of outputs related to wheel speed and acceleration are obtained and applied to develop the compass tilt estimation at 68, while the wheel speed factor is also applied to provide steering compensation at 76. Also applied to the latter are the turn rate (rate of change of heading) factor .omega..sub.m and a factor representing the wheel base of the cart, from which speed (velocity) compensation factors V.sub.x and V.sub.y are derived for application to table calculator 74.

Detailed Description Text (32):
The north and east wheel speed outputs of 74 are integrated at 77, 78 with position error correction factors from the DGP S/DR calibration, and referenced to initial north and east positions P.sub.n (0) and P.sub.e (0) of the cart, to generate corrected north and east position information P.sub.n and P.sub.e, respectively.

The meanings attached to the symbols in FIG. 8 and related calculations or computations are described in detail in the '962 application.

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L7: Entry 1 of 1 File: USPT Sep 3, 2002

DOCUMENT-IDENTIFIER: US 6446005 B1
TITLE: Magnetic wheel sensor for vehicle navigation system

Brief Summary Text (7):
Distance measurements to three GPS satellites are used to accurately define the position of an object such as a GPS receiver, which may be stationary or moving, on or near the earth's surface. A fourth satellite enables verification of clock timing in the GPS system. With several satellites in "view" (i.e., line-of-sight, or LOS), and using a computer, distances between objects can theoretically be measured almost instantaneously with great accuracy. But as a practical matter even small errors that typically occur in the calculated measurement of satellite signal travel time from system and natural phenomena can substantially reduce the accuracy of the distance and position calculations. Error causing phenomena include atmospheric propagation, receiver contributions, satellite ephemeris, and satellite clock. Errors have been purposely introduced in the satellite signals by the government to deny civilian users full accuracy. The combined effect of these errors can be as high as 100 meters or so.

Brief Summary Text (8):
In co-pending patent application Ser. Nos. 08/423,295 (now U.S. Pat. No. 5,689,431) and 08/525,905, filed Apr. 18, 1995 and Sep. 8, 1995, respectively, assigned to the same assignee as the present application ("The '295 and '905 applications"), improvements are disclosed in golf course positioning and yardage measuring systems utilizing differential GPS (DGPS) (see, for example, Blackwell, "Overview of Differential GPS Methods", Global Positioning System, vol. 3, pp. 89-100, The Institute of Navigation, Washington, D.C. (1986)). With DGPS, errors in distance measuring applications are reduced by broadcasting error correction information from a ground receiver of known location in the vicinity of the user. The difference between a known fixed position of a GPS receiver and its position calculated from the satellite GPS signal fixes the error in the signal, and a continuous correction is provided for all other receivers, fixed or mobile, in the reception area. Knowing the error allows all distance and position calculations at the user's receiver to be corrected.

Brief Summary Text (16):
The ACUTRAK system is golf cart-based, but could be packaged alternatively in smaller vehicles, even a set of golf bag wheels equipped with a mobile unit or a hand-held unit used with a pedometer version of the wheel-tracking system disclosed in the '962 application. That system utilizes virtually all of the features of the PROLINK system disclosed in the '295 and '905 applications, except that the ACUTRAK system places limited reliance on DGPS, using it as a calibration technique only. In its primary functions the ACUTRAK system employs a dead reckoning system that tracks distance moved by and orientation of the wheels, extrapolated to the heading or bearing of the golf cart (or other roving unit) in which a portion of the overall system is incorporated. The ACUTRAK system is unaffected by even frequent inability to view a satellite navigation system, such as the GPS satellites, requiring only relatively infrequent calibration during play to avoid a gradual increase or buildup of error in measurements as the cart is driven about the

course. Thus, instead of experiencing frequent out-of-service indications on the cart monitor, the golfer is cognizant only of continuous, reliable, highly accurate operation of the ACUTRAK system.

Brief Summary Text (19):
In the ACUTRAK system disclosed in the '962 application, the dead reckoning (DR, alternatively referred to as dead reckoning navigation or DRN) system is the golf cart navigator which determines distance (yardage) measurements as well as heading. Other information derived from DGPS is used solely to calibrate the DR errors in real time so that each cart is periodically calibrated and re-calibrated to survey points during play. With each calibration, accumulated DR errors are reduced such that wheel scale factor (SF) and compass misalignment errors become very small compared to the uncalibrated nominal errors. They are not completely eliminated, however, because of temperature changes, heating up of cart tires, and tilt effects on the compass. Nevertheless, the DR errors grow slowly after each calibration, so that accuracy of within approximately two yards on distance measurements for the yardage traversed on about a par 5 golf hole, which is a distance of about 500 yards, can be maintained. Generally, at some point on every fairway from tee box to green at least minimal LOS to GPS satellites is available so that calibration can be performed, and the calibration is automatic.

Brief Summary Text (33):
A global positioning system receiver of the cart receives differential GPS position signals which are used to re-calibrate the DR wheel sensor assembly at least once during play of each hole to restore a level of accuracy to the calculation of distance by substantially removing error buildup arising since the previous calibration.

Brief Summary Text (34):
Using the invention, a method is provided for performing a relatively accurate calculation of the distance of the ball to a feature of interest on a hole of a golf course which has been surveyed so that the locations of various features on each hole are known. A golf cart on which a dead reckoning navigation (DRN) system is installed (including the magnetic wheel sensor assembly for determining speed and direction of the golf cart and the compass for determining heading of the golf cart during movement thereof and ultimately determining the position of the golf cart) is positioned adjacent a tee box of a hole to be played on the course, as an origin of coordinates for the relative position of the golf cart. After a tee shot, the golf cart is repositioned adjacent the new position of the ball resulting from that shot. As the golf cart is being repositioned, the coordinates of the new position of the ball relative to the origin are determined from the DRN system. Using the new position coordinates in conjunction with the known position coordinates of the cup for the hole being played, the approximate distance from the new position of the ball to the cup is ascertained. At least once during play of a hole, the DRN system is re-calibrated to restore a level of accuracy of measurements by the DRN system by substantially removing error buildup since the previous calibration of the DRN system from the determinations.

Detailed Description Text (4):
A dead reckoning system can provide information at rates of hundreds of times per second, enable measurement of yardage to a fraction of an inch at any sampling instant, and is not susceptible to masking that would preclude GPS yardage measurements. Dead reckoning systems are limited, however, by sources of error that grow with distance traveled. Using a wheel sensor to measure distance and a compass to measure bearing or heading, as in the present invention, error sources include wheel scale factor (SF), magnetic heading variation error, sensor noise, and wheel spin, as well as potential compass-based errors. For example, tire pressure affects wheel diameter which can produce related error in measurement of distance traveled. It is necessary to provide a capability to estimate errors and to apply corrections so that golf course yardage is measured with accuracy using the dead reckoning

system.

Detailed Description Text (7):
Referring to FIG. 2, a block diagram for a generalized DR navigator using differential GPS (DGPS) calibration, DR sensors 15 provide a golf cart state vector which is corrupted by errors that grow with time and/or distance. GPS receiver 16 provides observations of the pseudo-range and range rate to each GPS satellite in LOS view. Errors in these observations are corrected to an appropriate extent by use of a digital radio system 17 which receives DGPS corrections of pseudo-range and range rate. The corrections are processed using conventional DGPS correction processing 18 to obtain more accurate observations of these parameters for the respective golf cart.

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